US009454097B2

(12) **United States Patent**
Takahashi et al.

(10) **Patent No.: US 9,454,097 B2**
(45) **Date of Patent: Sep. 27, 2016**

(54) **DEVELOPING DEVICE HAVING COMMUNICATION PORTION AND CONVEYING MEMBER TO CONVEY DEVELOPING AGENT**

(71) Applicant: **Brother Kogyo Kabushiki Kaisha**, Nagoya-shi, Aichi-ken (JP)

(72) Inventors: **Keisuke Takahashi**, Nagoya (JP); **Kazutoshi Kotama**, Toyota (JP)

(73) Assignee: **Brother Kogyo Kabushiki Kaisha**, Nagoya-shi, Aichi-ken (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/477,940**

(22) Filed: **Sep. 5, 2014**

(65) **Prior Publication Data**

US 2015/0086248 A1 Mar. 26, 2015

(30) **Foreign Application Priority Data**

Sep. 25, 2013 (JP) 2013-198744

(51) **Int. Cl.**
G03G 15/08 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/0812*** (2013.01); ***G03G 15/0808*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/0812; G03G 15/0808
USPC 399/258, 281, 284
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,885,223	A *	12/1989	Enoki et al.	430/122.1
5,561,506	A *	10/1996	Kasahara	399/256
6,125,250	A *	9/2000	Kamio et al.	399/98
6,229,980	B1	5/2001	Ogawa et al.	
2005/0111887	A1 *	5/2005	Choi et al.	399/281
2011/0135344	A1 *	6/2011	Ebe	399/281

FOREIGN PATENT DOCUMENTS

JP	H11-249426	A	9/1999
JP	2000-162873	A	6/2000
JP	2005-156694	A	6/2005
JP	2007-114482	A	5/2007

* cited by examiner

Primary Examiner — Billy Lactaoen
(74) *Attorney, Agent, or Firm* — Banner & Witcoff, Ltd.

(57) **ABSTRACT**

A developing device includes a housing, a developing roller, a supply roller, a first regulating member, a second regulating member, a communication portion, and a conveying member. The second regulating member contacts with the supply roller. The housing has a first part and a second part. The first part is downstream of the second regulating member in a rotating direction of the supply roller, and a second part is upstream of the second regulating member in the rotating direction. The communication portion provides communication between the first part and the second part. The conveying member is in the first part and configured to convey the developing agent in the first part to the communication portion.

13 Claims, 8 Drawing Sheets

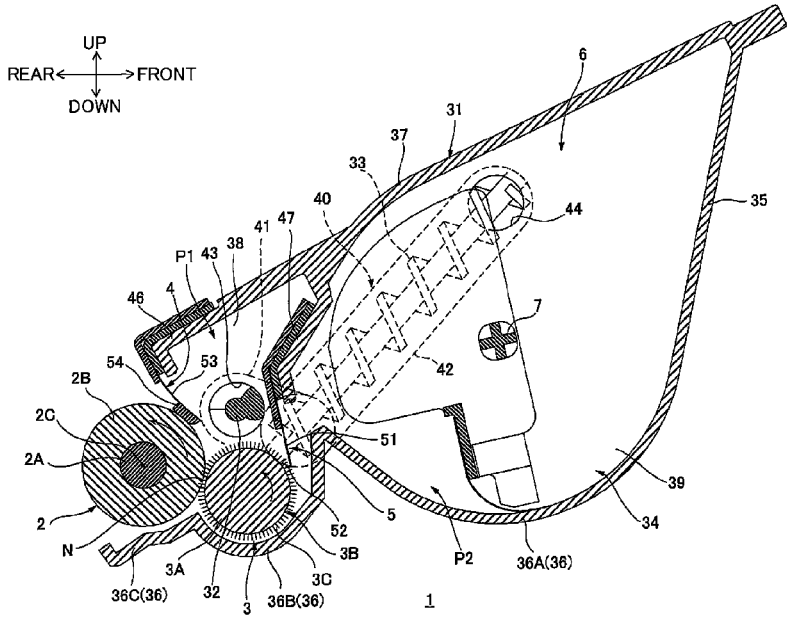


FIG. 1

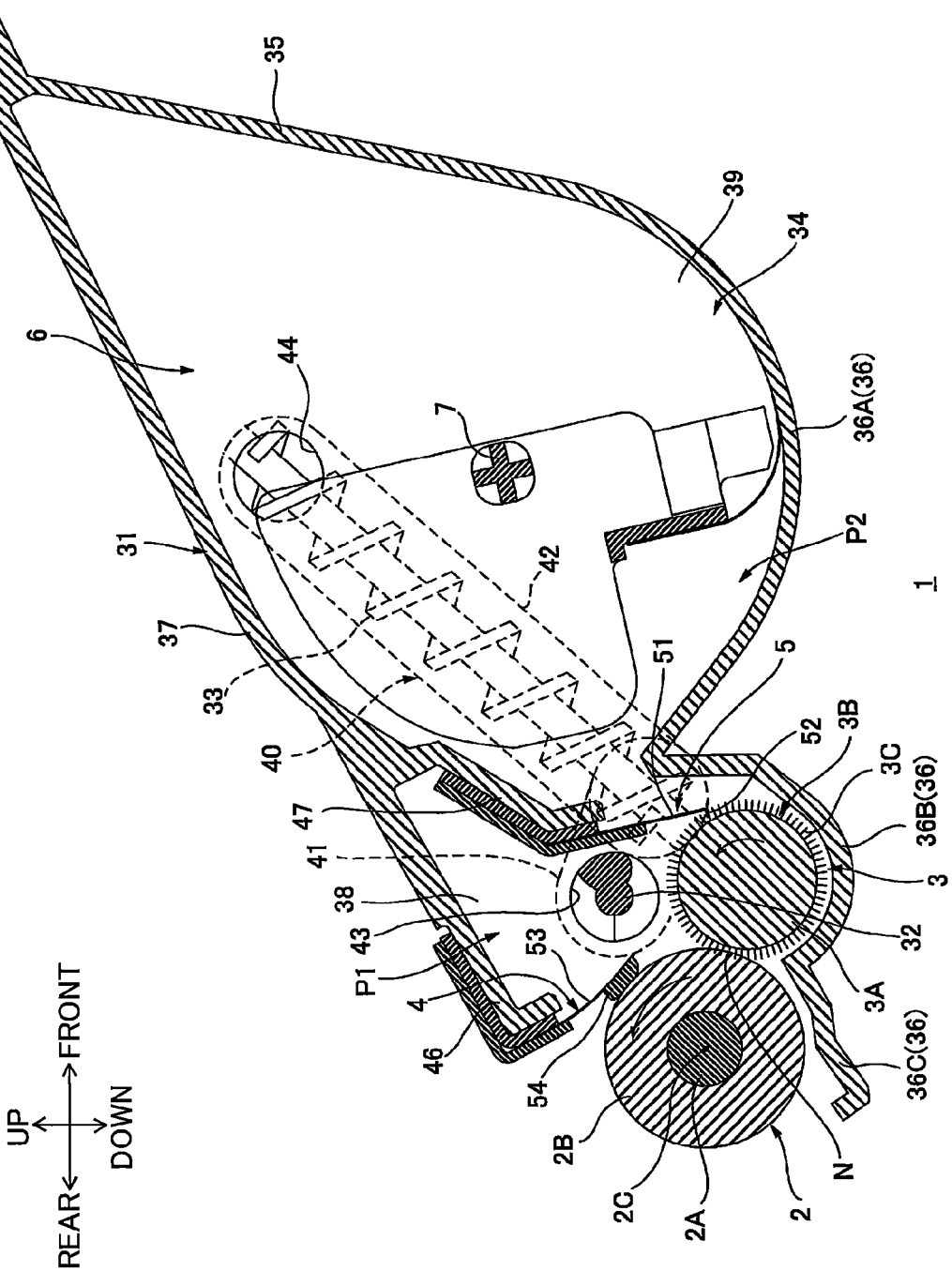

35
39
34
6
44
7
36A(36)
31
42
P2
37
33
40
51
5
52
3B
3C
36B(36)
47
41
38
43
P1
4
46
53
54
2B
2C
2A
2
N
3
32
3A
36C(36)
1
UP
FRONT
REAR
DOWN

FIG. 2

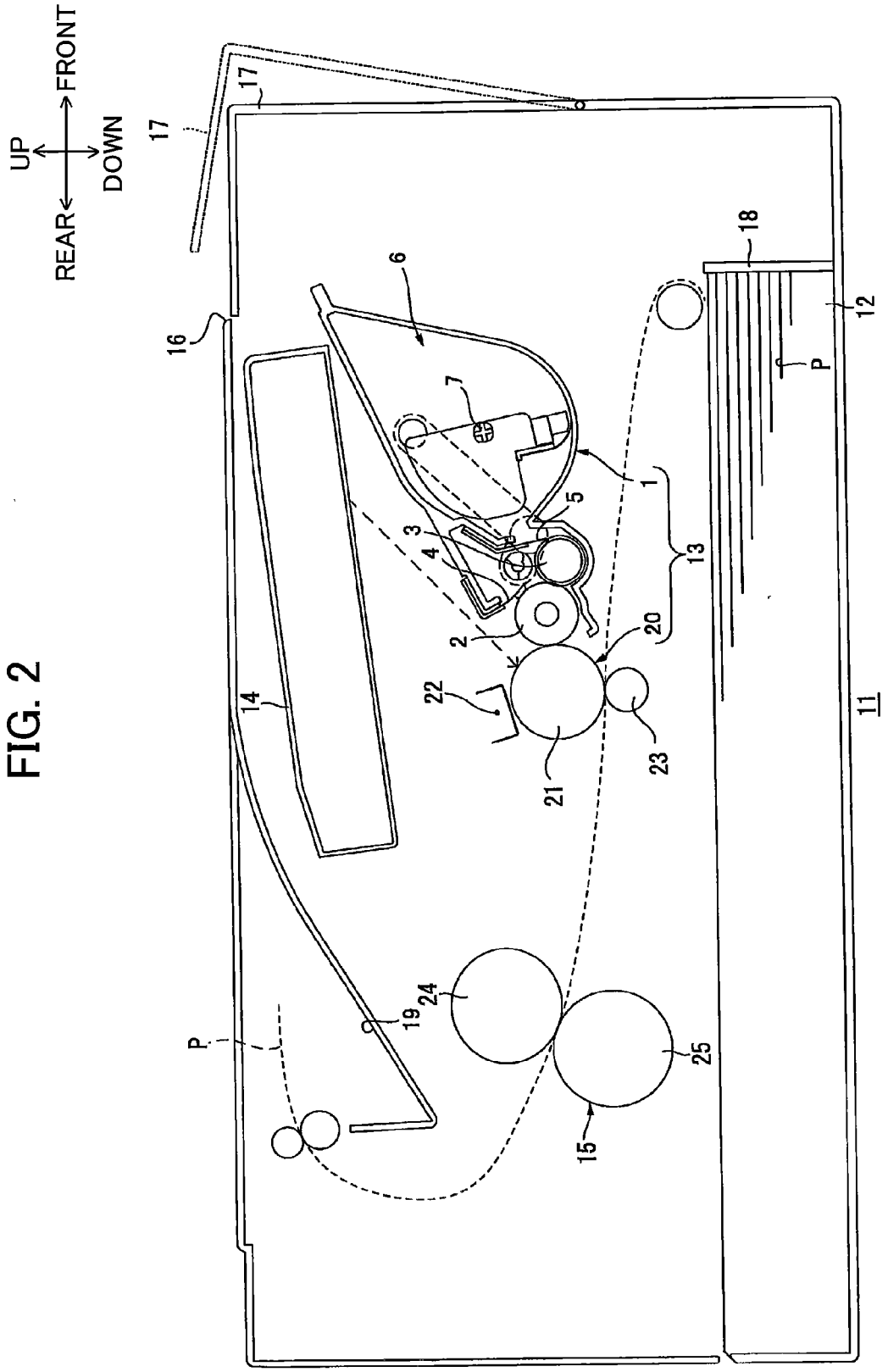

UP
FRONT
REAR
DOWN
17
17
16
6
7
1
5
3
4
2
13
20
18
12
P
14
22
21
23
11
19
24
25
15
P

FIG. 3

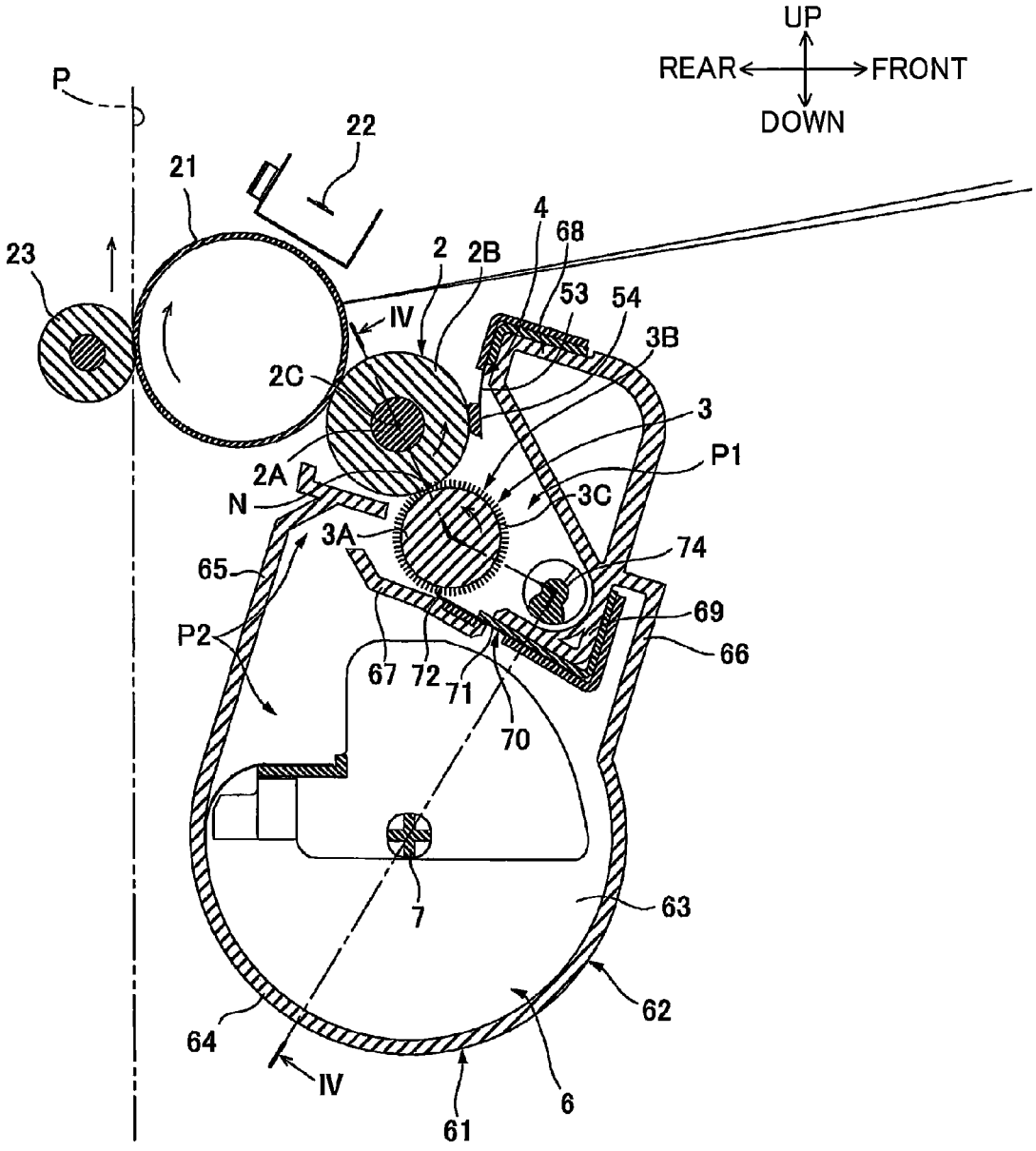

UP
REAR
FRONT
DOWN
P
22
21
23
4
68
2
2B
53
54
IV
3B
2C
3
P1
2A
N
3C
3A
74
65
69
P2
66
67
72
71
70
7
63
62
64
IV
6
61

FIG. 4

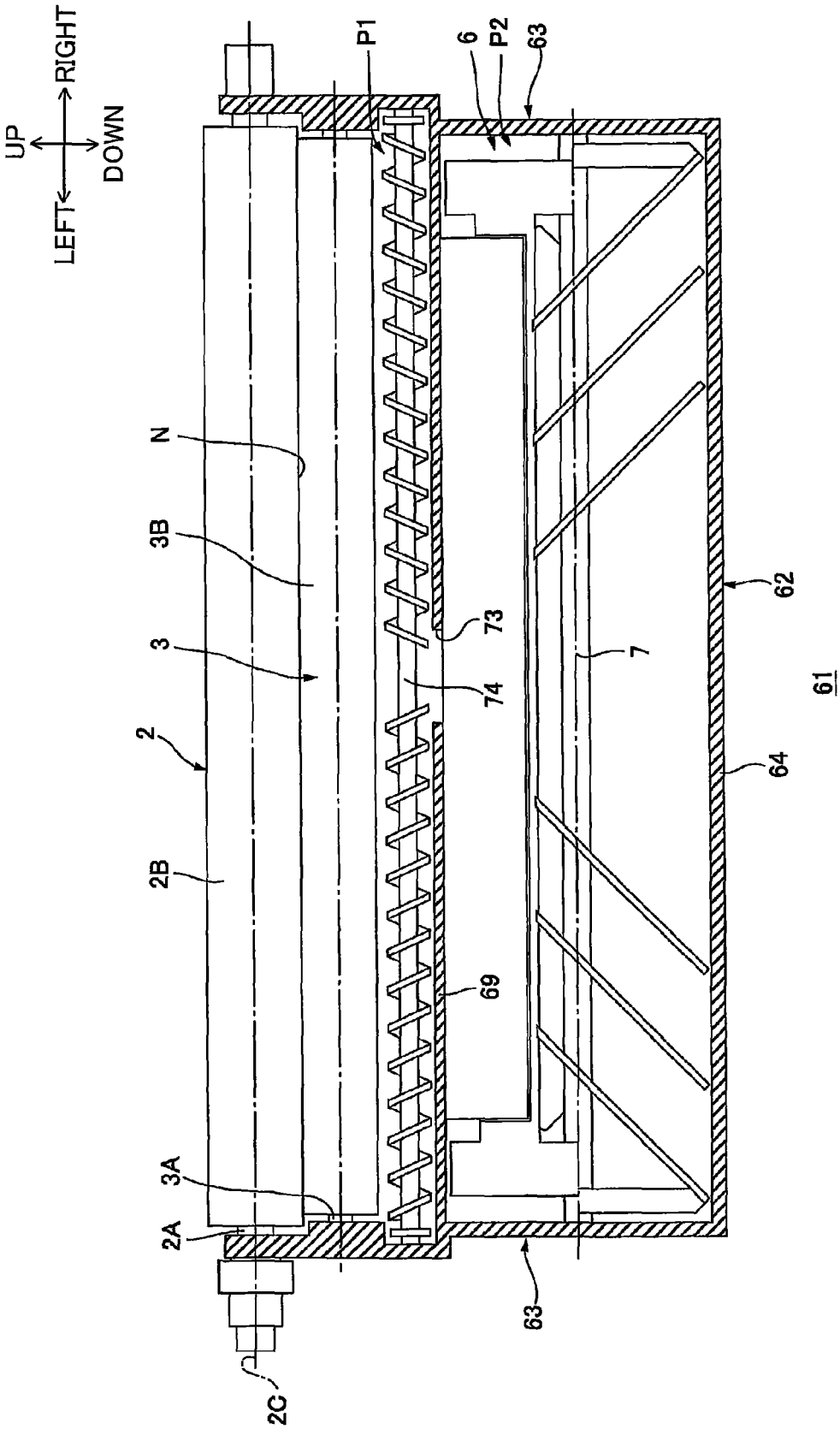

UP
RIGHT
DOWN
LEFT
P1
6
P2
63
N
3B
3
2
2B
3A
2A
2C
73
74
69
7
62
64
61
63

FIG. 5

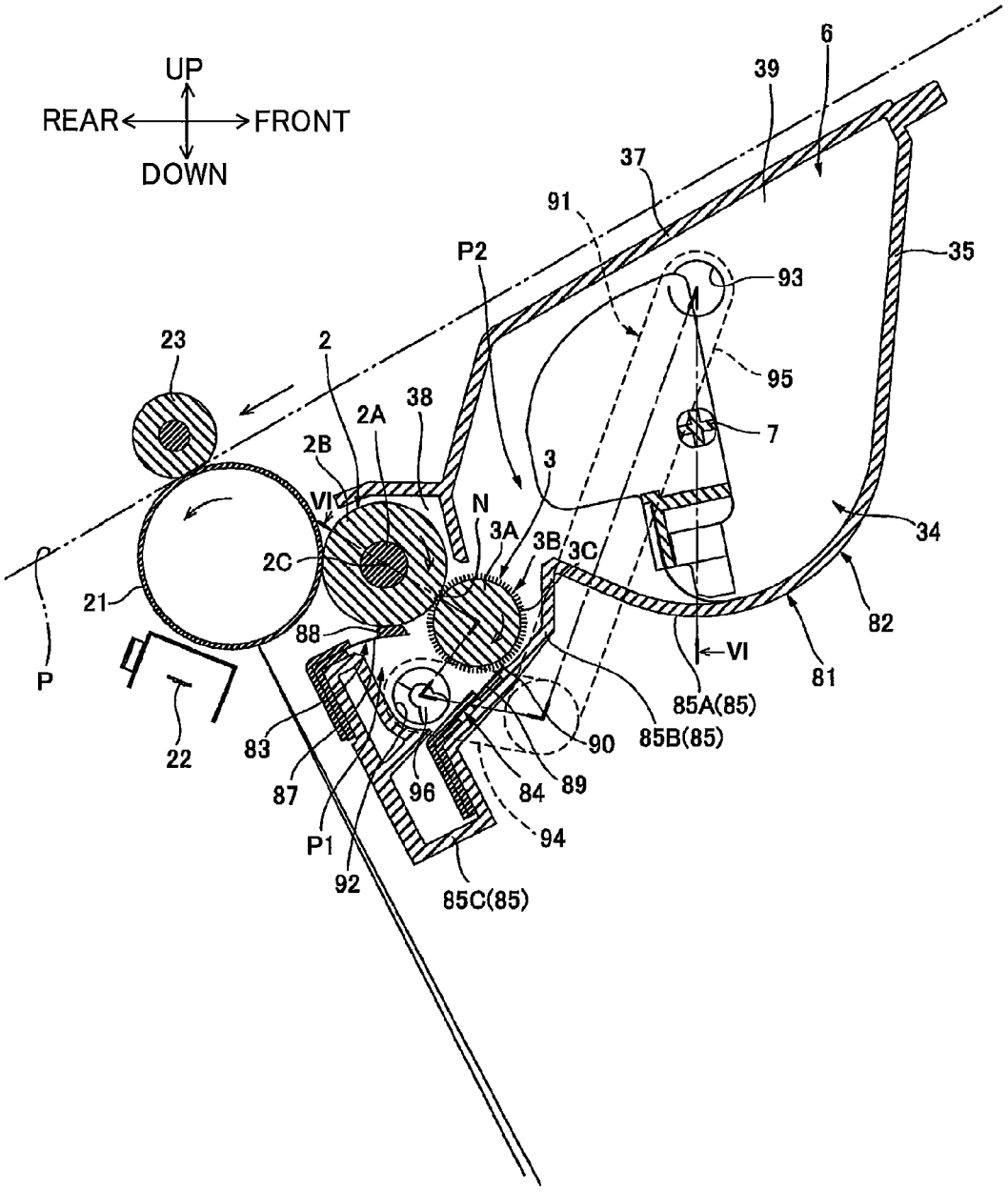

UP
REAR
FRONT
DOWN
6
39
37
91
35
P2
93
23
2
95
38
2A
7
2B
3
VI
N
34
3A
3B
3C
2C
21
82
88
VI
81
P
85A(85)
85B(85)
22
83
90
87
96
84
89
94
P1
92
85C(85)

FIG. 6

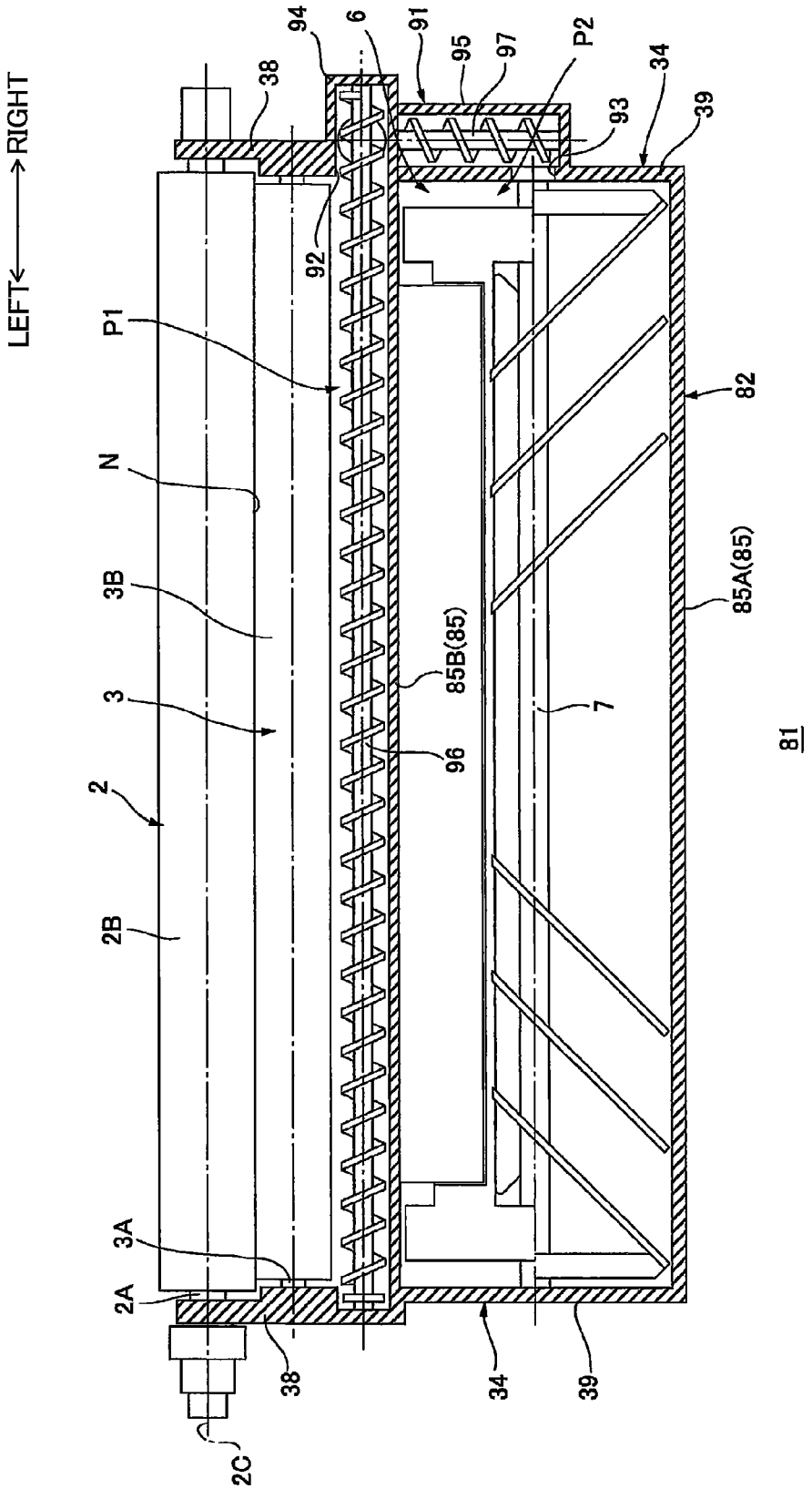

LEFT
RIGHT
94
6
91
95
97
P2
34
39
38
93
92
P1
82
N
3B
85A(85)
85B(85)
3
7
96
2
2B
81
3A
2A
38
34
39
2C

FIG. 7

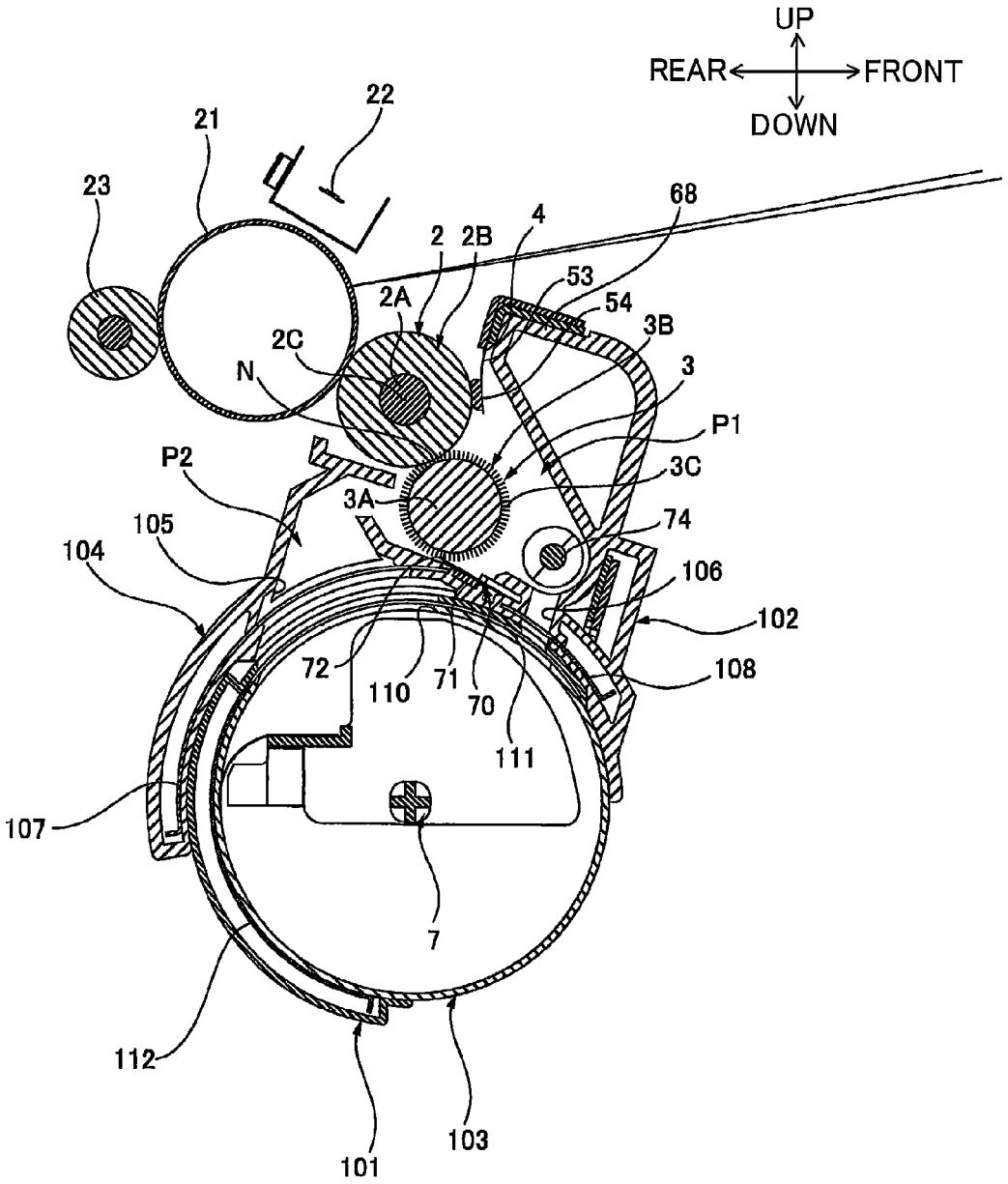
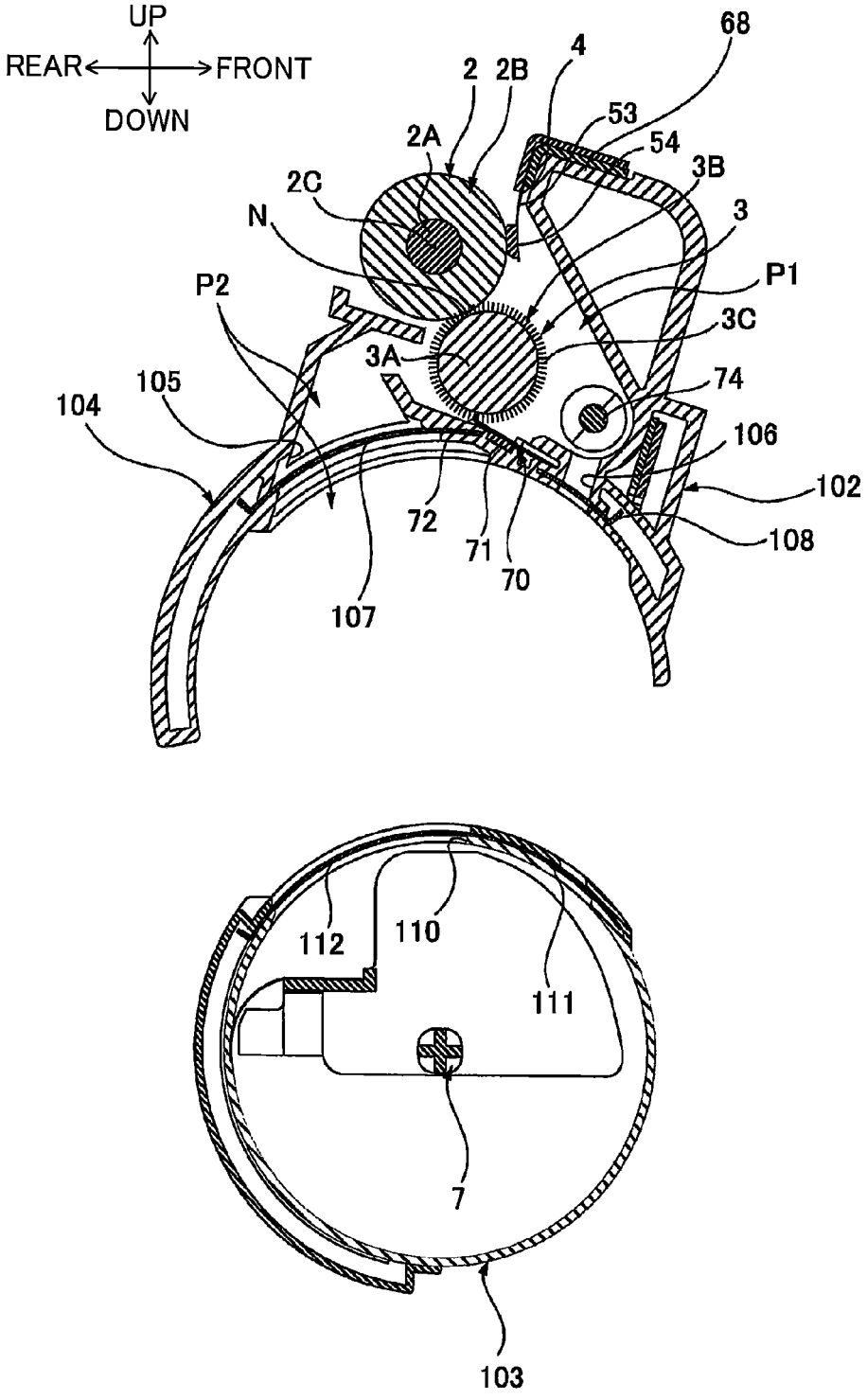

UP
REAR
FRONT
DOWN
22
21
23
68
4
2
2B
53
54
2A
3B
2C
N
3
P1
P2
3C
3A
74
105
104
106
102
72
110
71
70
108
111
107
7
112
101
103

FIG. 8


UP
REAR
FRONT
DOWN
68
4
2
2B
53
54
2A
3B
2C
3
N
P1
P2
3C
3A
74
105
104
106
102
72
108
71
70
107
112
110
111
7
103

DEVELOPING DEVICE HAVING COMMUNICATION PORTION AND CONVEYING MEMBER TO CONVEY DEVELOPING AGENT

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority from Japanese Patent Application No. 2013-198744 filed Sep. 25, 2013. The entire content of the priority application is incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to a developing device provided in an electro-photographic type image forming apparatus.

BACKGROUND

A conventional electro-photographic type image forming apparatus includes an image carrier for carrying an electrostatic latent image, and a developing device for supplying developing agent to the electrostatic latent image on the image carrier.

Japanese Patent Application Publication No. H11-249426 discloses a developing device provided in such electro-photographic type image forming apparatus. The developing device includes a developing roller for supplying toner (developing agent) to a photosensitive body (image carrier), and a fur brush for supplying toner to the developing roller. The disclosed developing device also includes a layer thickness regulating member for adjusting a toner on a surface of the developing roller to a constant amount, and an elastic blade for maintaining a constant amount of toner on a surface of the fur brush. The adjusting member is in contact with the surface of the developing roller by a total length thereof in an axial direction, and the elastic blade is in contact with the surface of the fur brush by a total length thereof in the axial direction.

SUMMARY

With this structure, the toner scraped from the surface of the developing roller by the layer thickness regulating member may be accumulated in a space between the elastic blade and the layer thickness regulating member.

The toner released from the surface of the developing roller may include toner subjected to insufficient electrification, and the accumulation of such faultily electrified toner in the space between the elastic blade and the layer thickness regulating member may result in a printing failure called "fogging".

Therefore, it is an object of this invention to provide a developing device capable of stabilizing image formation.

In order to attain the above and other objects, the present invention provides a developing device that includes a housing, a developing roller, a supply roller, a first regulating member, a second regulating member, a communication portion, and a conveying member. The housing includes a developing agent reservoir that may be configured to accommodate a developing agent. The developing roller has an axis that may extend in a first direction and a first outer peripheral surface that may be configured to carry the developing agent thereon. The developing roller may be supported by the housing and rotatable about the axis in a first rotating direction. The supply roller includes a core member and a brush portion. The core member may have a second outer peripheral surface and extend in parallel to the axis. The core member may be supported by the housing and rotatable in a second rotating direction. The brush portion may contain fibers implanted on the second outer peripheral surface and may be configured to contact the developing roller to supply the developing agent in the developing agent reservoir to the developing roller. A contact portion may be defined between the brush portion and the developing roller. The first regulating member has a first fixed portion and a first contacting portion. The first fixed portion may be fixed to the housing. The first contacting portion may contact the first outer peripheral surface at a position downstream of the contact portion in the first rotating direction, and may be configured to regulate the developing agent on the first outer peripheral surface to a constant thickness. The second regulating member has a second fixed portion and a second contacting portion. The second fixed portion may be fixed to the housing. The second contacting portion may contact the brush portion at a position upstream of the contact portion in the second rotating direction. The second contacting portion may be configured to regulate the developing agent on the supply roller to a constant amount. The housing may have a first part positioned downstream of the second regulating member in the second rotating direction and a second part positioned upstream of the second regulating member in the second rotating direction. The communication portion may be configured to provide communication between the first part and the second part. The conveying member may be positioned in the first part and configured to convey the developing agent in the first part to the communication portion.

According to another aspect, the present invention provides a developing device that includes a housing, a developing agent reservoir, a developing roller, a supply roller, a first regulating member, a second regulating member, a communication portion, and a conveying member. The developing agent reservoir may be detachably supported by the housing and may be configured to accommodate a developing agent. The developing roller may be supported by the housing and rotatable about the axis in a first rotating direction. The supply roller includes a core member and a brush portion. The core member may have a second outer peripheral surface and extend in parallel to the axis. The core member may be supported by the housing and rotatable in a second rotating direction. The brush portion may contain fibers implanted on the second outer peripheral surface and may be configured to contact the developing roller to supply the developing agent in the developing agent reservoir to the developing roller. A contact portion may be defined between the brush portion and the developing roller. The first regulating member has a first fixed portion and a first contacting portion. The first fixed portion may be fixed to the housing. The first contacting portion may contact the first outer peripheral surface at a position downstream of the contact portion in the first rotating direction, and may be configured to regulate the developing agent on the first outer peripheral surface to a constant thickness. The second regulating member has a second fixed portion and a second contacting portion. The second fixed portion may be fixed to the housing. The second contacting portion may contact the brush portion at a position upstream of the contact portion in the second rotating direction. The second contacting portion may be configured to regulate the developing agent on the supply roller to a constant amount. The housing may have a first part positioned downstream of the second regulating

member in the second rotating direction and a second part positioned upstream of the second regulating member in the second rotating direction. The communication portion may be configured to provide communication between the first part and the second part. The conveying member may be positioned in the first part and configured to convey the developing agent in the first part to the communication portion.

BRIEF DESCRIPTION OF THE DRAWINGS

The particular features and advantages of the invention as well as other objects will become apparent from the following description taken in connection with the accompanying drawings, in which:

FIG. **1** is a central cross-sectional view of a developing unit as an developing device according to a first embodiment of the present invention;

FIG. **2** is a central cross-sectional view of a printer provided with the developing unit shown in FIG. **1**;

FIG. **3** is a view for description of a developing unit according to a second embodiment of the present invention;

FIG. **4** is a cross-sectional view of the developing unit taken along a line IV-IV in FIG. **3**;

FIG. **5** is a view for description of a developing unit according to a third embodiment of the present invention;

FIG. **6** is a cross-sectional view of the developing unit taken along a line VI-VI in FIG. **5**;

FIG. **7** is a view for description of a developing unit according to a fourth embodiment of the present invention and showing a state where a toner cartridge is attached to a developing unit frame; and

FIG. **8** is a view for description of the developing unit according to the fourth embodiment and showing a state where the toner cartridge is detached from the developing unit frame.

DETAILED DESCRIPTION

1. Overall Structure of Developing Device

A developing unit **1** as an example of a developing device according to a first embodiment of the present invention will be described with reference to FIGS. **1** and **2**. The developing unit **1** has a developing roller **2**, a supply roller **3**, a thickness-regulating blade **4** as an example of a first regulating member, a second blade (toner amount regulating blade) **5** as an example of an second regulating member, and a toner accommodating portion **6** as an example of a developing agent reservoir.

Directions used in the following description in relation to the developing unit **1** will be referred to the state when the developing unit **1** is attached to a printer that will be described below, which defines the upper side and the lower side. Specifically, the upper side of FIG. **1** will be referred to as the "upper side", and the lower side of FIG. **1** as the "lower side". Further, the right side in FIG. **1** will be referred to as the "front side," and the left side as the "rear side." Further, left and right sides of the developing unit **1** in the following description will be based on the perspective of the user facing the front side of the printer **1**. Thus, the near side of the developing unit **1** in FIG. **1** will be considered the "left side," and the far side will be considered the "right side." The leftward/rightward direction is an example of first directions, and the rightward direction is an example of one of the first directions.

The developing roller **2** is disposed in a rear end portion of the developing unit **1**, and rotatable in a counterclockwise direction when viewed from the left side. The developing roller **2** includes a developing roller shaft **2**A and a developing roller body **2**B.

The developing roller shaft **2**A has a substantially cylindrical shape, and extends in the leftward/rightward direction. In other words, developing roller shaft **2**A has a center axis **2**C extending in the leftward/rightward direction. The center axis **2**C is an example of an axis. The developing roller shaft **2**A is made from metal.

The developing roller body **2**B has a substantially cylindrical shape, and extends in the leftward/rightward direction. The developing roller body **2**B is made from electrically conductive rubber. The developing roller body **2**B covers a center portion of the developing roller shaft **2**A, while left and right end portions of the developing roller shaft **2**A are uncovered.

The supply roller **3** is positioned frontward and downward of the developing roller **2**. The supply roller **3** is rotatable in the counterclockwise direction when viewed from the left side. The supply roller **3** has a supply roller shaft **3**A as an example of a core member, and a brush portion **3**B.

The supply roller shaft **3**A has a substantially cylindrical shape, and extends in the leftward/rightward direction parallel to the developing roller shaft **2**A. The supply roller shaft **3**A is made from metal.

The brush portion **3**B has electrically conductive fibers **3**C as examples of fibers implanted on an outer peripheral surface of the supply roller shaft **3**A. The brush portion **3**B covers a center portion of the supply roller shaft **3**A in the leftward/rightward direction, while left and right end portions of the supply roller shaft **3**A are uncovered. The brush portion **3**B is in contact with a front lower end portion of the developing roller body **2**B.

The thickness-regulating blade **4** is positioned frontward and upward of the developing roller **2**. The thickness-regulating blade **4** is in contact with a front end portion of the developing roller body **2**B.

The second blade **5** is disposed frontward and upward of the supply roller **3**. The second blade **5** is in contact with a front end portion of the brush portion **3**B.

The toner accommodating portion **6** is positioned frontward of the supply roller **3** and the second blade **5**. The toner accommodating portion **6** is configured to accommodate therein a toner as an example of a developing agent. The toner is a positively-chargeable non-magnetic single component type polymerized toner as an example of a chemical toner. Such polymerized toner is produced by a method described in Japanese Patent Application Publication No. 2008-186002. More specifically, the polymerized toner is obtained by blending together in a liquid phase a first polymerizable monomer, a charge-control resin, and a toner core particle. The first polymerizable monomer includes cationic radical. The charge-control resin is obtained by copolymerization of the first polymerizable monomer with a second polymerizable monomer copolymerizable therewith. The toner core particle contains coloring agent. The toner accommodating portion **6** is provided with an agitator **7**.

The agitator **7** is rotatably supported in the toner accommodating portion **6**.

2. Overall Structure of Printer Provided with the Developing Device

The image forming apparatus **11** is an electrophotographic type monochromatic printer, and has a main frame **12**, a

process unit **13**, a scanner unit **14**, and a fixing unit **15**. As illustrated in FIG. **2**, the developing unit **1** is attached to the main frame **12**.

The main frame **12** has a substantially box shape, and has an opening **16**, a front cover **17**, a sheet supply tray **18**, and a discharge tray **19**.

The opening **16** is positioned at a front end portion of the main frame **12**. The opening **16** permits communication between an interior and an exterior of the main frame **12** in the frontward/rearward direction so as to allow the process unit **13** to pass therethrough.

The front cover **17** is positioned at a front end portion of the main frame **12**, and is generally plate shaped. The front cover **17** extends in the upward/downward direction, and has a lower end portion pivotally movably connected to a front wall of the main frame **12** for opening and closing the opening **16**.

The sheet supply tray **18** is placed at a bottom portion of the main frame **12**, and configured to accommodate sheets P.

The discharge tray **19** is provided at a rear half portion of an upper wall of the main frame **12**. The discharge tray **19** is recessed downward from an upper face of the main frame **12** so that the sheets P can be accommodated thereon.

The process unit **13** is positioned in a substantially center portion in the upward/downward direction of the main frame **12**. The process unit **13** includes a drum unit **20** and the developing unit **1**.

The drum unit **20** includes a photosensitive drum **21**, a scorotron charger **22**, and a transfer roller **23**.

The photosensitive drum **21** is rotatably supported to a rear end portion of the drum unit **20**.

The scorotron charger **22** is positioned rearward of and away from the photosensitive drum **21**.

The transfer roller **23** is disposed below the photosensitive drum **21**, and in contact with a lower end portion of the photosensitive drum **21**.

The developing unit **1** is disposed forward of the photosensitive drum **21** and in contact with a front end portion of the photosensitive drum **21**.

The scanner unit **14** is positioned above the process unit **13**. The scanner unit **14** is configured to emit a laser beam corresponding to image data to the photosensitive drum **21**.

The fixing unit **15** is positioned rearward of the process unit **13**. The fixing unit **15** includes a heat roller **24**, and a pressure roller **25** in pressure contact with a rear lower end portion of the heat roller **24**.

During an image forming operation of the image forming apparatus **11**, the scorotron charger **22** uniformly charges a surface of the photosensitive drum **21**. Next, the surface of the photosensitive drum **21** is exposed to the laser beam emitted from the scanner unit **14**. Accordingly, an electrostatic latent image corresponding to image data is formed on the surface of the photosensitive drum **21**.

On the other hand, the agitator **7** agitates toner in the toner accommodating portion **6** so as to supply the toner to the supply roller **3**. The supply roller **3** conveys the toner supplied by the agitator **7** to the developing roller **2**. Simultaneously, the toner is charged with a positive polarity by the triboelectric charging between the developing roller **2** and the supply roller **3**, and held by the developing roller **2**. The thickness-regulating blade **4** regulates the thickness of the toner on the developing roller **2** to a constant thickness.

Subsequently, the toner on the developing roller **2** is supplied to the electrostatic latent image on the surface of the photosensitive drum **21**. Accordingly, a toner image is formed and carried on the surface of the photosensitive drum **21**.

Upon rotations of various rollers, each of the sheets P is conveyed from the sheet supply tray **18** to the contacting part of the photosensitive drum **21** and the transfer roller **23** in a prescribed timing. The toner image on the surface of the photosensitive drum **21** is transferred to the sheet P, as the sheet P passes through between the photosensitive drum **21** and the transfer roller **23**.

Subsequently, the sheet P is pressed and heated, when passing through between the heat roller **24** and the pressure roller **25**. As a result, the toner image on the sheet P is thermally fixed thereon, and the sheet P is then discharged onto the discharge tray **19**.

3. Details of the Developing Unit

(1) Developing Unit Frame

As depicted in FIG. **1**, the developing unit **1** includes a developing unit frame **31** as an example of a housing.

The developing unit frame **31** is substantially box shaped, and has a rear open end. The developing unit frame **31** is an integral member including a pair of side walls **34**, a lower wall **36**, front wall **35**, and upper wall **37**.

The side walls **34** are right and left end portions of the developing unit frame **31**. Each of the pair of the side walls **34** has a substantially plate shape extending in frontward/rearward direction, and includes a first wall **38** and a second wall **39**.

The first wall **38** occupies a rear half portion of the side wall **34**, and is positioned rearward of the toner accommodating portion **6**. The first wall **38** rotatably supports right and left end portions of the developing roller shaft **2**A and right and left end portions of the supply roller shaft **3**A.

The second wall **39** occupies a front half portion of the side wall **34**. The second walls **39** serve as left and right side walls of the toner accommodating portion **6**, and rotatably support left and right end portions of the agitator **7**.

The lower wall **36** constitutes a lower end portion of the developing unit frame **31**. The lower wall **36** is an integral component including a first wall **36**A, a second wall **36**B, and a third wall **36**C.

The first wall **36**A constitutes a front half portion of the lower end portion of the developing unit frame **31**.

The first wall **36**A has a generally arcuate-shaped cross-section, and also has a center portion in the frontward/rearward direction protruding downward. The first wall **36**A has left and right end portions each being continuous with each of lower end portions of the second walls **39** of the pair of the side walls **34**. The first wall **36**A forms a bottom wall of the toner accommodating portion **6**.

The second wall **36**B is positioned rearward of the first wall **36**A, and has a generally arcuate-shaped cross-section. The second wall **36**B is integral with and extends rearward from a rear end portion of the first wall **36**A, curving along an outer peripheral surface of the supply roller **3**. The second wall **36**B has left and right end portions each being continuous with each of front lower end portions of each of the first walls **38**.

The third wall **36**C is positioned rearward of the second wall **36**B. The third wall **36**C has a generally linear cross-section. The third wall **36**C is integral with and extends rearward from a rear end portion of the second wall **36**B. The third wall **36**C has left and right end portions each being continuous with each of rear lower end portions of each first wall **38**.

The front wall **35** constitutes a front end portion of the developing unit frame **31**. The front wall **35** has a substantially plate shape extending upward from a front end portion

of the lower wall **36**. The front wall **35** has left and right end portions each being continuous with each of front end portions of each second wall **39**. The front wall **35** serves as a front wall of the toner accommodating portion **6**.

The upper wall **37** constitutes an upper end portion of the developing unit frame **31**. The upper wall **37** is substantially plate-shaped, and extends in the frontward/rearward direction. The upper wall **37** has a front end portion continuous with an upper end portion of the front wall **35**. The upper wall **37** has left and right end portions each being continuous with each of upper end portions of each of the pair of the side walls **34**. The upper wall **37** supports a thickness-regulating blade support portion **46** and a second blade support portion **47**.

The thickness-regulating blade support portion **46** is disposed at a rear end portion of the upper wall **37**, and extends in the frontward/rearward direction. The thickness-regulating blade support portion **46** has a plate shape that forms a substantially L-shaped cross-section bending downward at a rear end portion thereof. The thickness-regulating blade support portion **46** supports the thickness-regulating blade **4**.

The thickness-regulating blade **4** includes a main portion **53**, and a contact part **54** as an example of a first contacting portion.

The main portion **53** has a plate shape extending in the upward/downward direction and elongated in the leftward/rightward direction. The main portion **53** has an upper end portion fixed to a rear face of a rear end portion of the thickness-regulating blade support portion **46**, and also has a lower end portion facing a front upper end portion of the developing roller body **2**B. The upper end portion of the main portion **53** is an example of a first fixed portion.

The contact part **54** is positioned at a rear face of a lower end portion of the main portion **53**. The contact part **54** extends in the leftward/rightward direction, and has a curved rear end portion forming a generally arcuate cross-section. The contact part **54** is in contact with a front upper end portion of the developing roller body **2**B. That is, the contact part **54** is in contact with the developing roller body **2**B at a position downstream of a contact portion N in the rotating direction of the developing roller **2**. Here, the contact portion N is a contacting portion between the developing roller **2** and the supply roller **3**, and the rotating direction is the counterclockwise direction when viewed from the left side of the developing roller body **2**B.

The second blade support portion **47** is positioned at a substantially intermediate portion of the upper wall **37** in the frontward/rearward direction. The second blade support portion **47** has a plate shape forming a generally crank-shaped cross-section extending from a lower face of the upper wall **37** and bending downward. The second blade support portion **47** has left and right end portions each being continuous with each of interior faces in the leftward/rightward direction of each of the pair of the side walls **34**. The second blade support portion **47** has a lower end portion positioned rearward and upward of a rear end portion of the first wall **36**A, and the lower end portion of the second blade support portion **47** is spaced away from the rear end portion of the first wall **36**A. The second blade support portion **47** supports the second blade **5**.

The second blade **5** integrally includes a main portion **51** and a regulation portion **52** as an example of a second contacting portion.

The main portion **51** has a plate shape extending in the upward/downward direction and elongated in the leftward/rightward direction. The main portion **51** has an upper end portion fixed to a front face of a rear end portion of the second blade support portion **47**, and has a lower end portion whose rear side faces a front upper end portion of the supply roller **3**. That is, the main portion **51** extends from the second blade support portion **47** to the supply roller **3**. The upper end portion of the main portion **51** is an example of a second fixed portion.

The regulation portion **52** has a generally L-shaped cross-section extending from a lower end portion of the main portion **51** and bending toward the supply roller shaft **3**A. The regulation portion **52** has a free end portion entering the brush portion **3**B. That is, regulation portion **52** is in contact with the brush portion **3**B at a position upstream of the contact portion N in the rotating direction of the supply roller **3**. Here, the contact portion N is a contacting portion between the developing roller **2** and the supply roller **3**, and the rotating direction is the counterclockwise direction when viewed from the left side of the supply roller **3**.

The developing unit frame **31** forms a first part P**1**, which is an area surrounded by the developing roller **2**, the supply roller **3**, the thickness-regulating blade **4**, the second blade **5**, the pair of the side walls **34**, and the upper wall **37**. Additionally, the developing unit frame **31** forms a second part P**2**, which is an area forward of the second blade **5** in the developing unit frame **31**.

(2) Conveyance of Toner

The developing unit **1** further includes a conveying unit **40** as an example of a communication portion, and a first screw **32** as an example of a conveying member.

The conveying unit **40** is disposed outward of the right side wall **34**, i.e. rightward of the right side wall **34**. The conveying unit **40** includes a first opening **43**, a second opening **44**, a first conveying portion **41**, a second conveying portion **42**, and a second screw **33** as an example of a second conveying member.

The first opening **43** is located at a substantially intermediate portion of the right first wall **38** in the upward/downward direction, and is positioned forward and upward of the developing roller **2** and above the supply roller **3**. The first opening **43** is substantially circular shaped, and penetrates the right first wall **38** in the leftward/rightward direction.

The second opening **44** is positioned at an upper end portion of a substantially intermediate portion in the frontward/rearward direction of the right second wall **39**. The second opening **44** is generally circular shaped, and penetrates the right second wall **39** in the leftward/rightward direction.

The first conveying portion **41** has a generally cylindrical shape extending forward and downward from a peripheral portion of the first opening **43**. The first conveying portion **41** has a rear upper end portion communicating with the first opening **43**.

The second conveying portion **42** is generally cylindrical shaped. The second conveying portion **42** is continuous with a front lower end portion of the first conveying portion **41**, and extends forward and upward. The second conveying portion **42** has a rear lower end portion communicating with the front lower end portion of the first conveying portion **41**, and has a front upper end portion communicating with the second opening **44**. Accordingly, the conveying unit **40** provides communication between the first part P**1** and the upper end portion of the toner accommodating portion **6**, i.e. the second part P**2**.

The second screw **33** is disposed in the second conveying portion **42**. The second screw **33** is an auger screw extending in the rear downward/front upward direction. The second screw **33** has a front upper end portion that is rotatably

supported by a front upper wall of the second conveying portion **42**, and has a rear lower end portion that is rotatably supported by a rear lower wall of the second conveying portion **42**.

The first screw **32** is positioned frontward of the developing roller **2** and above the supply roller **3**. The first screw **32** is an auger screw extending in the leftward/rightward direction. The first screw **32** has a left end portion rotatably supported by the left side wall **34**, and has a right end portion rotatably supported by the right wall of the first conveying portion **41**.

4. Operation of the Developing Unit

Upon starting operation of the image forming apparatus **11**, toner in the toner accommodating portion **6** is supplied to the supply roller **3** by the agitator **7**.

Next, the toner is carried by the brush portion **3**B. Part of the toner carried by the brush portion **3**B is scraped by the regulation portion **52** to be regulated to a constant amount.

Subsequently, the toner that is not scraped by the regulation portion **52** but remaining on the brush portion **3**B is charged with a positive polarity by the triboelectric charging at the contact portion N between the developing roller **2** and the supply roller **3**. The toner is then carried on a surface of the developing roller body **2**B.

The toner on the developing roller body **2**B is regulated to a constant thickness by the contact part **54** of the thickness-regulating blade **4**, as developing roller **2** rotates in the counterclockwise direction when viewed from the left side.

Simultaneously, the toner scraped from the surface of the developing roller body **2**B is accumulated around the contact portion N between the developing roller **2** and the supply roller **3**. That is, the toner is accumulated in the first part P**1**.

The toner accumulated around the contact portion N is conveyed rightward by the first screw **32**, and then supplied to the first conveying portion **41** through the first opening **43**.

The toner supplied to the first conveying portion **41** is moved by gravity to the rear lower end portion of the second conveying portion **42**, and then is conveyed forward and upward by the second screw **33**. Thus, the toner is supplied to the upper end portion of the toner accommodating portion **6**, i.e. the second part P**2**, through the second opening **44**.

5. Operational Advantages

(1) In the developing unit **1** according to the embodiment described above, as shown in FIG. **1**, the toner scraped by the thickness-regulating blade **4** is conveyed by the first screw **32** to the conveying unit **40** from the first portion P**1** positioned downstream of the second blade **5** in the rotating direction of the supply roller **3**. Consequently, the toner can be returned to the toner accommodating portion **6** positioned upstream of the second blade **5** in the rotating direction of the supply roller **3** through the conveying unit **40**.

Accordingly, the accumulation of the toner scraped by the thickness-regulating blade **4** in the first part P**1** can be suppressed. Therefore, the accumulation of the toner subjected to insufficient electrification in the first part P**1** can be suppressed, and the image formation can be stabilized.

(2) As shown in FIG. **1**, the developing unit **1** includes the conveying unit **40**, which provides communication between the first part P**1** and the upper end portion of the toner accommodating portion **6**. Thus, the toner in the first part P**1** can be returned to the upper end portion of the toner accommodating portion **6**. Consequently, the return process of the toner in the first part P**1** to the toner accommodating portion **6** can be smoothly carried out without being affected by the accommodation amount of the toner in the toner accommodating portion **6**.

(3) In the developing unit **1**, the conveying unit **40** is positioned at the right end portion of the developing unit frame **31**, and the first screw **32** conveys the toner in the first part P**1** rightward. Thus, the toner in the first part P**1** can be collected rightward. As a result, the toner in the first part P**1** can be further efficiently returned to the toner accommodating portion **6**.

(4) As shown in FIG. **1**, the developing unit **1** further includes the second screw **33** positioned in the second conveying portion **42** of the conveying unit **40** for conveying the toner in the conveying unit **40** to the toner accommodating portion **6**. Therefore, the toner conveyed to the conveying unit **40** can be surely conveyed to the toner accommodating portion **6** by the second screw **33**.

(5) The toner employed in the developing unit **1** is a chemical toner that is manufactured by polymerizing polymerizable monomers. Because of the employment of the chemical toner that has a good fluidity, the amount of the toner carried on the supply roller **3** can be easily adjusted. Specifically, the second blade **5** can facilitate regulation of the toner amount. That is, the second blade **5** can suppress excessive invasion of the toner into the brush portion **3**B, and thus generation of excessive torque at the contact portion N between the developing roller **2** and the supply roller **3** can be suppressed. Consequently, the image formation can be further stabilized.

(6) As shown in FIG. **1**, the second blade **5** in the developing unit **1** has the main portion **51** extending to the supply roller **3**, and the regulation portion **52**. The regulation portion **52** continuous with the main portion **51** is bent toward the supply roller shaft **3**A, and is entered into the brush portion **3**B. Accordingly, part of the toner on the brush portion **3**B can be surely scraped by the regulation portion **52** entering the brush portion **3**B. As a result, the toner amount on the brush portion **3**B can be uniformly regulated, and thus a further stabilized image formation can be obtained. Moreover, the torque at the contact portion N can be reduced.

6. Second Embodiment

A developing unit **61** according to a second embodiment of the present invention will next be described with reference to FIGS. **3** and **4** wherein like parts and components are designated by the same reference numerals as those shown in FIGS. **1** and **2** to avoid duplicating description.

(1) Outline of the Second Embodiment

The developing unit **61** according to the second embodiment provides the toner accommodating portion **6** below the supply roller **3** as shown in FIG. **3**, whereas the developing unit **1** according to the first embodiment provides the toner accommodating portion **6** frontward of the supply roller **3**.

The developing unit **61** according to the second embodiment is applied to an image forming apparatus that conveys the sheet P upward, while the developing unit **1** according to the first embodiment is applied to the image forming apparatus **11** that conveys the sheet P rearward.

(2) Detailed Structure of the Developing Unit

(2-1) Developing Unit Frame

The developing unit **61** includes a developing unit frame **62** as an example of a housing, as shown in FIGS. **3** and **4**. The developing unit frame **62** is substantially box shaped and has an upper open end. The developing unit frame **62** is

an integral member including a pair of side walls **63**, a lower wall **64**, a rear wall **65**, a front wall **66**, and a partition wall **67**.

The pair of side walls **63** are right and left end portions of the developing unit frame **62**, and each side wall **63** has a substantially plate shape extending in the vertical direction. Each side wall **63** has a rear upper end portion rotatably supporting the developing roller shaft **2**A. Further, each side wall **63** has a front lower end portion rotatably supporting the supply roller shaft **3**A so that the brush portion **3**B is in contact with the front lower end portion of the developing roller body **2**B.

The lower wall **64** constitutes a rear lower end portion of the developing unit frame **62**. The lower wall **64** has a generally arcuate-shaped cross-section. The lower wall **64** has an intermediate portion in the frontward/rearward direction protruding downward, and has left and right end portions each being in continuous with each lower end portion of each side wall **63**.

The rear wall **65** constitutes a rear end portion of the developing unit frame **62**. The rear wall **65** has a generally plate shape extending upward from and continuous with the rear end portion of the lower wall **64**. The rear wall **65** has left and right end portions each being continuous with each of rear end portions of the pair of the side walls **63**.

The front wall **66** constitutes a front end portion of the developing unit frame **62**. The front wall **66** has a substantially plate shape extending upward from and continuous with a front end portion of the lower wall **64**. The front wall **66** has left and right end portions each being continuous with each of front end portions of the pair of the side walls **63**. The front wall **66** has a thickness-regulating blade support portion **68** and a second blade support portion **69**.

The thickness-regulating blade support portion **68** is positioned at an upper end portion of the front wall **66**, and has a generally triangular cross-section having a rear vertex portion. The thickness-regulating blade support portion **68** supports the thickness-regulating blade **4**.

The thickness-regulating blade **4** has a main portion **53** and a contact part **54**. The main portion **53** has an upper end portion fixed on a rear face of the upper end portion of the front wall **66**. The contact part **54** is in contact with a front upper end portion of the developing roller body **2**B. That is, the contact part **54** is in contact with the developing roller body **2**B at a position downstream of a contact portion N in the rotating direction of the developing roller **2**. Here, the contact portion N is a contacting portion between the developing roller **2** and the supply roller **3**.

The second blade support portion **69** is positioned at a substantially intermediate portion in the upward/downward direction of the front wall **66**. The second blade support portion **69** has a plate shape that forms a substantially L-shaped cross-section extending downward from a lower end portion of the thickness-regulating blade support portion **68** and bending rearward. The second blade support portion **69** has left and right end portions each being continuous with each of interior faces in the leftward/rightward direction of the pair of the side walls **34**. The second blade support portion **69** supports the second blade **70**.

The second blade **70** is an integral member including a main portion **71** and a regulation portion **72** as an example of a second contacting portion. The second blade **70** forms a penetration hole (not shown) facing a communication hole **73** as will be described later.

The main portion **71** has a plate shape elongated in the leftward/rightward direction and extending in the frontward/rearward direction. The main portion **71** has a front end portion fixed on a lower face of a rear end portion of the second blade support portion **69**. The main portion **71** has a rear end portion facing a lower end portion of the supply roller **3**. That is, the main portion **71** extends to the supply roller **3** from the front end portion. The front end portion of the main portion **71** is an example of a second fixed portion.

The regulation portion **72** has a generally L-shaped cross-section continuous with the rear end portion of the main portion **71** and bending upward to the supply roller shaft **3**A. The regulation portion **72** has an end portion entering the brush portion **3**B of the supply roller **3**. That is, the regulation portion **72** is in contact with the brush portion **3**B at a position upstream of the contact portion N in the rotating direction of the supply roller **3**. Here, the contact portion N is a contacting portion between the developing roller **2** and the supply roller **3**.

The partition wall **67** is positioned below the supply roller **3** in an intermediate portion in the upward/rearward direction of the developing unit **61**. The partition wall **67** has a generally plate shape extending in the frontward/rearward direction. The partition wall **67** has a front end portion positioned blow a rear end portion of the second blade **70**, and has a rear end portion positioned frontward of and spaced away from an upper end portion of the rear wall **65**.

The developing unit frame **62** defines a first part P**1**, which is demarcated by the developing roller **2**, the supply roller **3**, the thickness-regulating blade **4**, the second blade **70**, the pair of the side walls **63**, and the front wall **66**. Additionally, the developing unit frame **62** also defines a second part P**2**, which is an area rearward of the supply roller **3** and below the partition wall **67**.

(2-2) Conveyance of Toner

The developing unit **61** is formed with the communication hole **73** and further includes a screw **74** as an example of a conveying member. The communication hole **73** is positioned at a substantially intermediate portion in the leftward/rightward direction of a lower wall of the second blade support portion **69**. The communication hole **73** vertically penetrates the lower wall of the second blade support portion **69**.

The screw **74** is positioned frontward of the supply roller **3** and above the lower wall of the second blade support portion **69**. That is, the screw **74** is positioned lower than the developing roller **2**. The screw **74** is an auger screw extending in the leftward/rightward direction. The screw **74** has a right half portion having a left-hand thread or helix and a left half portion having a right-hand thread or helix. The screw **74** has a left end portion rotatably supported by the left side wall **63**, and has a right end portion rotatably supported by the right side wall **63**.

(3) Operation in Developing Unit

Upon starting the image forming operation, toner in the toner accommodating portion **6** is supplied to the supply roller **3** through between a rear end portion of the partition wall **67** and the rear wall **65**, as the agitator **7** rotates in the clockwise direction when viewed from the left side.

Next, the toner is carried by the brush portion **3**B of the supply roller **3**. Part of the toner on the brush portion **3**B is regulated by the regulation portion **72** of the second blade **70** to a constant amount, as the supply roller **3** rotates in the counterclockwise direction when viewed from the left side.

Subsequently, the toner that is not scraped by the regulation portion **72** but remaining on the brush portion **3**B is charged with a positive polarity by the triboelectric charging at the contact portion N between the developing roller **2** and the supply roller **3**. The toner is thus carried on the surface of the developing roller body **2**B.

The toner on the developing roller body **2**B is regulated to a constant thickness by the contact part **54** of the thickness-regulating blade **4**, as the developing roller **2** rotates in the counterclockwise direction when viewed from the left side.

Simultaneously, the toner scraped from the surface of the developing roller body **2**B is accumulated on a space in front of the supply roller **3**, i.e. accumulated in the first part P**1**.

The toner accumulated at the front side of the supply roller **3** is conveyed to an intermediate portion in the leftward/rightward direction by the screw **74**, and is then supplied to the upper end portion of the toner accommodating portion **6**, i.e. the second part P**2**, thorough the communication hole **73** and the penetration hole (not shown) of the second blade **70**.

(4) Operational Advantages

(4-1) In the developing unit **61** according to the second embodiment, as shown in FIG. **3**, the screw **74** is positioned lower than the developing roller **2**. Accordingly, the toner scraped by the thickness-regulating blade **4** from the developing roller **2** can be moved by gravity downward of the developing roller **2**. This geometry can prevent the toner scraped from the developing roller **2** from being resupplied to the developing roller **2** before returning to the toner accommodating portion **6**.

(4-2) In the developing unit **61** according to the second embodiment, the toner accommodating portion **6** is positioned below the developing roller **2** as shown in FIG. **3**. Accordingly, the toner must be supplied from the toner accommodating portion **6** to the developing roller **2** against gravity, and therefore may cause problems, such as shortage or instability of the toner supply to the developing roller **2**. However, in the developing unit **61** according to the second embodiment, the supply roller **3** has the brush portion **3**B. Accordingly, the brush portion **3**B can convey a sufficient amount of the toner, and therefore can supply a sufficient amount of the toner to the developing roller **2**.

Moreover, the second blade **5** can regulate the toner on the brush portion **3**B to a constant amount. Accordingly, stabilized amount of the toner can be supplied to the developing roller **2** from the supply roller **3**.

Accordingly, the amount of the toner supplied to the developing roller **2** from the supply roller **3** can be stabilized.

(4-3) Additionally, the developing unit **61** according to the second embodiment can provide further advantages the same as those of the developing unit **31** according to the first embodiment.

7. Third Embodiment

A developing unit **81** according to a third embodiment of the present invention will next be described with reference to FIGS. **5** and **6** wherein like parts and components are designated by the same reference numerals as those shown in FIGS. **1** and **2** to avoid duplicating description.

(1) Outline of the Third Embodiment

The developing unit **81** according to the third embodiment is applied to an image forming apparatus that conveys the sheet P rearward in an upper portion of the developing unit **1** as shown in FIG. **5**, whereas the developing unit **1** according to the first embodiment is applied to the image forming apparatus **11** that conveys the sheet P rearward in the lower portion of the developing unit **1**.

(2) Detailed Structure of the Developing Unit

The developing unit **81** according to the third embodiment includes a developing unit frame **82** having a lower wall **85**. The lower wall **85** is an integral member including a first wall **85**A, a second wall **85**B, and a third wall **85**C. The lower wall **85** supports a thickness-regulating blade **83** and a second blade **84**.

The first wall **85**A constitutes a front half portion of the developing unit frame **82**, similarly to the first wall **36**A of the lower wall **36** of the first embodiment. The first wall **85**A has a generally arcuate-shaped cross-section, and also has a substantially intermediate portion in the frontward/rearward direction protruding downward. The first wall **85**A has left and right portions each being continuous with each lower end portion of the second walls **39** of the pair of side walls **34**. The first wall **85**A constitutes a bottom wall of the toner accommodating portion **6**.

The second wall **85**B is positioned rearward of the first wall **85**A. The second wall **85**B is continuous with and extends downward from a rear end portion of the first wall **85**A, and bends downward and diagonally rearward. The second wall **85**B has left and right end portions each being continuous with each front lower end portion of the first walls **38** of the pair of the side walls **34**.

The third wall **85**C is positioned rearward of the second wall **85**B, and has a rectangular cross-section. The third wall **85**C extends downward from a rear end portion of the second wall **85**B, and has a lower end portion bent rearward. The third wall **85**C has a rear end portion bent upward from the lower end portion, and has a rear upper end portion positioned rearward and downward of the developing roller **2**. The third wall **85**C has a left and right end portions each being continuous with each rear lower end portion of the first walls **38** of the pair of the side walls **34**.

The thickness-regulating blade **83** has a main portion **87** and a contact part **88** as an example of a first contacting portion.

The main portion **87** has a generally plate shape extending in the frontward/rearward direction and elongated in the leftward/rightward direction. The main portion **87** has a rear end portion fixed on an upper face of a rear upper end portion of the third wall **85**C. The main portion **87** has a front end portion facing a lower end portion of the developing roller body **2**B. The rear end portion of the main portion **87** is an example of a first fixed portion.

The contact part **88** is positioned on an upper face of a front end portion of the main portion **87**. The contact part **88** extends in the leftward/rightward direction, and has an upper end portion forming a generally arcuate-shaped cross-section. The contact part **88** is in contact with the lower end portion of the developing roller body **2**B. That is, the contact part **88** is in contact with the developing roller body **2**B at a position downstream of a contact portion N in the rotating direction of the developing roller **2**. Here, the contact portion N is a contacting portion between the developing roller **2** and the supply roller **3**, and the rotating direction of the developing roller **2** is the clockwise direction when viewed from the left side.

The second blade **84** is an integral member including a main portion **89** and a regulation portion **90** as an example of a second contacting portion.

The main portion **89** has a substantially plate shape extending in the front upward/rear downward direction and elongated in the leftward/rightward direction. The main portion **89** has a rear lower end portion fixed on an upper face of a connecting portion between the second wall **85**B and the third wall **85**C. The main portion **89** has a front upper end portion facing a lower end portion of the supply roller **3**. That is, the main portion **89** extends from its rear

lower end portion to the supply roller **3**. The rear lower end portion of the main portion **89** is an example of a second fixed portion.

The regulation portion **90** has a generally L-shaped cross-section extending from a front upper end portion of the main portion **89** and bending toward the supply roller shaft **3**A. The regulation portion **90** has a free end portion entering the brush portion **3**B. That is, regulation portion **90** is in contact with the brush portion **3**B at a position upstream of the contact portion N in the rotating direction of the supply roller **3**. Here, the contact portion N is a contacting portion between the developing roller **2** and the supply roller **3**.

The developing unit frame **82** defines a first part P**1**, which is an area demarcated by the developing roller **2**, the supply roller **3**, the thickness-regulating blade **83**, the second blade **84**, the pair of the side walls **34**, and the third wall **85**C of the lower wall **85**. Additionally, the developing unit frame **82** forms a second part P**2**, which is an area frontward and upward of the supply roller **3** in the developing unit frame **82**.

(3) Conveyance of Toner

The developing unit **81** further includes a conveying unit **91** as an example of a communication portion.

The conveying unit **91** is positioned outward of the right side wall **34**, i.e. rightward of the right side wall **34**. The conveying unit **91** has a first opening **92** and a second opening **93**, and includes a first conveying portion **94**, a second conveying portion **95**, a first screw **96** as an example of a first conveying member, and a second screw **97** as an example of a second conveying member.

The first opening **92** is located at a substantially intermediate portion in the upward/downward direction of the first wall **38** of the right side wall **34**, and is positioned rearward and upward of the supply roller **3** and downward of the developing roller **2**. The first opening **92** is substantially circular shaped in the side view, and penetrates the right first wall **38** in the leftward/rightward direction.

The second opening **93** is located at a substantially upper end portion and intermediate portion in the frontward/rearward direction of the second wall **39** of the right side wall **34**. The second opening **93** is substantially circular shaped in the side view, and penetrates the right second wall **39** in the leftward/rightward direction.

The first conveying portion **94** has a generally cylindrical shape extending in the frontward/rearward direction. The first conveying portion **94** has a closed right end portion, and has an open left end portion communicating with the first opening **92**.

The second conveying portion **95** is generally cylindrical shaped. The second conveying portion **95** is continuous with a front lower end portion of the first conveying portion **94**, and extends forward and upward from the front lower end portion. The second conveying portion **95** has a rear lower end portion communicating with the front lower end portion of the first conveying portion **94**, and has a front upper end portion communicating with the second opening **93**.

The first screw **96** is positioned rearward and downward of the supply roller **3** and downward of the developing roller **2**. The first screw **96** is an auger screw extending in the leftward/rightward direction having right-hand thread or helix. The first screw **96** has a left end portion rotatably supported by the left side wall **34**, and has a right end portion rotatably supported by the right wall of the first conveying portion **94**.

The second screw **97** is disposed in the second conveying portion **95**. The second screw **97** is an auger screw extending in the rear downward/front upward direction having right-hand thread or helix. The second screw **97** has a front upper end portion that is rotatably supported by a front upper wall of the second conveying portion **95**, and has a rear lower end portion that is rotatably supported by a rear lower wall of the second conveying portion **95**.

(4) Operation in Developing Unit

Upon starting the image forming operation, toner in the toner accommodating portion **6** is supplied to the supply roller **3**, as the agitator **7** rotates in the clockwise direction when viewed from the left side.

Next, the toner is carried by the brush portion **3**B of the supply roller **3**. Part of the toner on the brush portion **3**B is regulated by the regulation portion **90** of the second blade **84** to a constant amount, as the supply roller **3** rotates in the clockwise direction when viewed from the left side.

Subsequently, the toner that is not scraped by the regulation portion **90** but remaining on the brush portion **3**B is charged with a positive polarity by the triboelectric charging at the contact portion N between the developing roller **2** and the supply roller **3**. The toner is thus carried on the surface of the developing roller body **2**B.

The toner on the surface of the developing roller body **2**B is regulated to a constant thickness by the contact part **88** of the thickness-regulating blade **83**, as the developing roller **2** rotates in the clockwise direction when viewed from the left side.

Simultaneously, the toner scraped from the surface of the developing roller body **2**B is accumulated on a space rearward and downward of the supply roller **3**, i.e. accumulated in the first part P**1**.

The toner accumulated rearward and downward of the supply roller **3** is conveyed rightward by the first screw **96**, and is then supplied to the first conveying portion **94** thorough the first opening **92**.

The toner supplied to the first conveying portion **94** can be moved by gravity to a rear lower end portion of the second conveying portion **95**, and then conveyed frontward and upward. Next, the toner is supplied through the second opening **93** into the upper end portion of the toner accommodating portion **6**, i.e. the second part P**2**.

(5) Operational Advantages

The developing unit **81** according to the third embodiment can provide advantages the same as those of the developing unit **31** according to the first embodiment.

8. Fourth Embodiment

A developing unit **101** according to a fourth embodiment of the present invention will next be described with reference to FIGS. **7** and **8** wherein like parts and components are designated by the same reference numerals as those shown in FIGS. **1** and **2** to avoid duplicating description.

(1) Outline of the Fourth Embodiment

The developing unit frame **62** according to the second embodiment is an integral member including the toner accommodating portion **6**.

On the contrary to the second embodiment, the developing unit **101** according to the fourth embodiment includes a developing unit frame **102** and a toner cartridge **103**, and the toner cartridge **103** is detachable to the developing unit frame **102** as shown in FIGS. **7** and **8**.

(2) Detailed Structure of the Developing Unit

The developing unit frame **102** is an example of a housing, and the toner cartridge **103** is an example of a developing agent reservoir.

(2-1) The developing unit frame **102** has a cartridge support portion **104** instead of the toner accommodating portion **6**, unlike the developing unit frame **62** according to the second embodiment.

The cartridge support portion **104** constitutes a lower end portion of the developing unit frame **102**. The cartridge support portion **104** has a semi-cylindrical shape extending in the leftward/rightward direction. The cartridge support portion **104** forms an open lower end, a supply hole **105**, and recovery hole **106** as an example of an communication portion, and includes a first shutter **107** and a second shutter **108**.

The supply hole **105** is positioned at a substantially intermediate portion in the frontward/rearward direction of the cartridge support portion **104**, and vertically penetrates the cartridge support portion **104**. The supply hole **105** communicates with a rear portion of the developing unit frame **102**, the rear portion being rearward of the supply roller **3**.

The recovery hole **106** is positioned forward of and away from the supply hole **105**, and is formed on a front end portion of the cartridge support portion **104**. The recovery hole **106** vertically penetrates the cartridge support portion **104**, and communicates with a front portion of the developing unit frame **102**, the front portion being frontward of the supply roller **3**.

The first shutter **107** is supported at a rear half portion of the cartridge support portion **104**. The first shutter **107** is a curved plate bent along the curved surface of the cartridge support portion **104** in the frontward/rearward direction. The first shutter **107** is slidable in the frontward/rearward direction between a close position and an open position. Here, the close position is the position of the first shutter **107** that closes the supply hole **105** (FIG. **8**), and the open position is a retracted position of the first shutter **107** that is rearward of the supply hole **105** and opens the supply hole **105** (FIG. **7**).

The second shutter **108** is supported at the front end portion of the cartridge support portion **104**. The second shutter **108** is a curved plate bent along the curved surface of the cartridge support portion **104** in the frontward/rearward direction. The second shutter **108** is slidable in the frontward/rearward direction between a close position and an open position. Here, the close position is a position of the second shutter **108** that closes the recovery hole **106** (FIG. **8**), and the open position is a retracted position of the second shutter **108** that is frontward of the recovery hole **106** and opens the recovery hole **106** (FIG. **7**).

The developing unit **101** according to the fourth embodiment defines a second part P**2**, which is an area including the cartridge support portion **104** and a rear portion of the developing unit frame **102** with respect to the supply roller **3**.

(2-2) Toner Cartridge

The toner cartridge **103** is detachably supported by the cartridge support portion **104** of the developing unit frame **102** in a lower end portion of the developing unit **101**. The toner cartridge **103** has a generally cylindrical shape extending in the leftward/rightward direction, and has a supply hole **110**, a recovery hole **111**, and a shutter **112**.

The supply hole **110** is positioned at an upper end portion and a generally intermediate portion in the frontward/rearward direction of the toner cartridge **103**. The supply hole **110** vertically penetrates an upper peripheral wall of the toner cartridge **103**, and is communicable with the supply hole **105** of the developing unit frame **102**.

The recovery hole **111** is positioned frontward of and spaced away from the supply hole **110**, and is formed on a front upper end portion of the toner cartridge **103**. The recovery hole **111** vertically penetrates an upper peripheral wall of the toner cartridge **103**, and is communicable with the recovery hole **106** of the developing unit frame **102**.

The shutter **112** is supported by the upper end portion of the toner cartridge **103**. The shutter **112** is a curved plate bent along the curved peripheral surface of the toner cartridge **103**. The shutter **112** is slidable in the frontward/rearward direction between a close position and an open position. Here, the close position is a position of the shutter **112** that closes the supply hole **110** and the recovery hole **111** (FIG. **8**), and the open position is a retracted position of the shutter **112** that is rearward and downward of the supply hole **110** and opens the supply hole **110** and the recovery hole **111** (FIG. **7**).

(3) Attachment and Detachment of the Toner Cartridge

For attaching the toner cartridge **103** to the developing unit frame **102**, firstly, the toner cartridge **103** is attached to the cartridge support portion **104** of the developing unit frame **102** as shown in FIG. **7**. Secondly, the first shutter **107** and the second shutter **108** of the developing unit frame **102** are respectively moved to the open positions, and the shutter **112** of the toner cartridge **103** is also moved to the open position.

For detaching the toner cartridge **103** from the developing unit frame **102**, firstly, the first shutter **107** and the second shutter **108** of the developing unit frame **102** are respectively moved to the close positions as shown in FIG. **8**. The shutter **112** of the toner cartridge **103** is also moved to the close position. Secondly, the toner cartridge **103** is detached from the cartridge support portion **104** of the developing unit frame **102**.

(4) Operation of the Developing Unit

Upon starting the image forming operation, toner in the toner cartridge **103** is supplied to the supply roller **3** sequentially through the supply hole **110** of the toner cartridge **103** and the supply hole **105** of the cartridge support portion **104**, as the agitator **7** rotates in the clockwise direction when viewed from the left side.

Next, the toner is carried by the brush portion **3**B of the supply roller **3**. Part of the toner on the brush portion **3**B is regulated by the regulation portion **72** of the second blade **70** to a constant amount, as the supply roller **3** rotates in the counterclockwise direction when viewed from the left side.

Subsequently, the toner that is not scraped by the regulation portion **72** but remaining on the brush portion **3**B is charged with a positive polarity by the triboelectric charging at the contact portion N between the developing roller **2** and the supply roller **3**. The toner is thus carried on the surface of the developing roller body **2**B.

The toner on the developing roller body **2**B is regulated to a constant thickness by the contact part **54** of the thickness-regulating blade **4**, as the developing roller **2** rotates in the counterclockwise direction when viewed from the left side.

Simultaneously, the toner scraped from the surface of the developing roller body **2**B is accumulated on a space in front of the supply roller **3**, i.e. accumulated in the first part P**1**.

The toner accumulated at the front side of the supply roller **3** is conveyed to the intermediate portion in the leftward/rightward direction by the screw **74**, and is then supplied to the upper end portion of the toner cartridge **103** sequentially thorough the recovery hole **106** of the cartridge support portion **104** and the recovery hole **111** of the toner cartridge **103**.

(5) Operational Advantages

The developing unit **101** according to the fourth embodiment can provide advantages the same as those of the developing unit **61** according to the second embodiment.

While the present invention has been described in detail with reference to the embodiments thereof, it would be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention.

What is claimed is:

1. A developing device comprising:

a housing including a developing agent reservoir configured to accommodate a developing agent;

a developing roller having a rotational axis extending in a first direction and a first outer peripheral surface configured to carry the developing agent thereon, the developing roller being supported by the housing and rotatable about the rotational axis in a first rotating direction;

a supply roller comprising:

a core member having a second outer peripheral surface and extending in parallel to the rotational axis, the core member being supported by the housing and rotatable in a second rotating direction; and

a brush portion containing fibers implanted on the second outer peripheral surface and configured to contact the developing roller to supply the developing agent in the developing agent reservoir to the developing roller, a contact portion being defined between the brush portion and the developing roller;

a first regulating member having a first fixed portion fixed to the housing, and a first contacting portion contacting the first outer peripheral surface at a position downstream of the contact portion in the first rotating direction and upstream, in the first rotating direction of a developing position where the developing agent is to be supplied to a photosensitive drum, the first contacting portion being configured to regulate the developing agent on the first outer peripheral surface to a constant thickness;

a second regulating member having a second fixed portion fixed to the housing, and a second contacting portion contacting the brush portion at a position upstream of the contact portion in the second rotating direction, the second contacting portion being configured to regulate the developing agent on the supply roller to a constant amount, the housing having a first part positioned downstream of the second regulating member in the second rotating direction of the supply roller and upstream of the first regulating member in the first rotating direction of the developing roller, and a second part positioned upstream of the second regulating member in the second rotating direction of the supply roller;

a communication portion configured to provide communication between the first part positioned downstream of the second regulating member in the second rotating direction of the supply roller and upstream of the first regulating member in the first rotating direction of the developing roller, and the second part positioned upstream of the second regulating member in the second rotating direction of the supply roller; and

a conveying member positioned in the first part and configured to convey the developing agent in the first part to the communication portion in the first direction in which the rotational axis of the developing roller extends.

2. The developing device according to claim **1**, wherein the developing agent reservoir has an upper portion; and

wherein the communication portion is configured to provide communication between the first part and the upper portion.

3. The developing device according to claim **1**, wherein the housing has an end portion in the first direction;

wherein the communication portion is provided at the end portion; and

wherein the conveying member is configured to convey the developing agent in the first part toward the end portion.

4. The developing device according to claim **1**, wherein the conveying member is positioned lower than the developing roller.

5. The developing device according to claim **1**, further comprising a second conveying member positioned in the communication portion and configured to convey the developing agent in the communication portion to the second part.

6. The developing device according to claim **1**, wherein the second regulating member has a main portion extending to the supply roller from the second fixed portion; and

wherein the second contacting portion is continuous with the main portion, and bends toward the core member to enter the brush portion.

7. The developing device according to claim **1**, wherein the first rotating direction is coincident with the second rotating direction.

8. A developing device comprising:

a housing;

a developing agent reservoir detachably supported by the housing and configured to accommodate a developing agent;

a developing roller having a rotational axis extending in a first direction and a first outer peripheral surface configured to carry the developing agent thereon, the developing roller being supported by the housing and rotatable about the rotational axis in a first rotating direction;

a supply roller comprising:

a core member having a second outer peripheral surface and extending in parallel to the rotational axis, the core member being supported by the housing and rotatable in a second rotating direction; and

a brush portion containing fibers implanted on the second outer peripheral surface and configured to contact the developing roller to supply the developing agent in the developing agent reservoir to the developing roller, a contact portion being defined between the brush portion and the developing roller;

a first regulating member having a first fixed portion fixed to the housing, and a first contacting portion contacting the first outer peripheral surface at a position downstream of the contact portion in the first rotating direction and upstream, in the first rotating direction of a developing position where the developing agent is to be supplied to a photosensitive drum, the first contacting portion being configured to regulate the developing agent on the first outer peripheral surface to a constant thickness;

a second regulating member having a second fixed portion fixed to the housing, and a second contacting portion contacting the brush portion at a position upstream of the contact portion in the second rotating direction, the second contacting portion being configured to regulate the developing agent on the supply roller to a constant amount, the housing having a first part positioned

downstream of the second regulating member in the second rotating direction of the supply roller and upstream of the first regulating member in the first rotating direction of the developing roller, and a second part positioned upstream of the second regulating member in the second rotating direction of the supply roller;

a communication portion configured to provide communication between the first part positioned downstream of the second regulating member in the second rotating direction of the supply roller and upstream of the first regulating member in the first rotating direction of the developing roller, and the second part positioned upstream of the second regulating member in the second rotating direction of the supply roller; and

a conveying member positioned in the first part and configured to convey the developing agent in the first part to the communication portion in the first direction in which the rotational axis of the developing roller extends.

9. The developing device according to claim **8**, wherein the developing agent reservoir has an upper portion; and

wherein the communication portion is configured to provide communication between the first part and the upper portion.

10. The developing device according to claim **8**, wherein the housing has an end portion in the first direction;

wherein the communication portion is provided at the end portion; and

wherein the conveying member is configured to convey the developing agent in the first part toward the end portion.

11. The developing device according to claim **8**, wherein the conveying member is positioned lower than the developing roller.

12. The developing device according to claim **8**, wherein the second regulating member has a main portion extending to the supply roller from the second fixed portion; and

wherein the second contacting portion is continuous with the main portion, and bends toward the core member to enter the brush portion.

13. The developing device according to claim **8**, wherein the first rotating direction is coincident with the second rotating direction.

* * * * *